THE FUNGICIDAL ACTION OF ULTRA-VIOLET RADIATION

W. A. R. Dillon Weston and E. T. Halnan

"PRINTED IN U. S. A."

[Reprinted from Phytopathology, December, 1930, Vol. XX, No. 12]

[Reprinted from Phytopathology, December, 1930, Vol. XX, No. 12]

THE FUNGICIDAL ACTION OF ULTRA-VIOLET RADIATION

W. A. R. Dillon Weston and E. T. Halnan[1]

It is the purpose of this paper to describe some recent work on the action of ultra-violet light on some specific fungi. At the time this work was initiated the writers were unaware that Fulton[2] had progressed so far in his experiments. Since, however, it is thought that some useful purpose will be served by outlining the work that we have recently carried out, the following resumé is here presented.

EXPERIMENTAL PROCEDURE

Source of light.—The lamp used was a quartz mercury-vapor lamp (Hanovia Artificial Alpine Sun, 2.5 amp. 210 v. direct-current type). The intensity of the light produced was roughly calibrated at intervals by means of the Erythema Dosimeter as devised by P. Keller.

Materials.—Potato agar was used as a medium for culturing the fungi that were selected for experiment. Eighteen petri dishes were used to contain this. The top cover was replaced, however, by a special form of glass, either Vita glass or Sanalux glass being used for this purpose. The medium was inoculated with the appropriate fungus from pure culture, a needle being used to introduce the organism. These dishes were irradiated for different periods and then compared with controls. The latter were similar cultures made in the same way but either with the ordinary petri dish cover or Sanalux or Vita glass for coverings. They were not irradiated.

Preliminary experiments.—The following fungi were selected for experiment: *Mucor Mucedo* L., *Rhizopus nigricans* Ehr., *Sporodinia grandis* Link, *Cladosporium herbarum* (Pers.) Link, *Dematium pullulans* de Bary and Löw, *Pleospora herbarum* (Pers.) Rabh., *Neurospora sitophila* Shear and Stev., *Fusarium* sp., *Sclerotinia trifoliorum* Eriks., and *Stereum purpureum* Pers. Cultures of these were made and on the same day radiation was commenced. In these preliminary experiments, they were irradiated for 9 minutes a day (this corresponds to 2 A.S.U.), the treatment being continued daily for a fortnight in the case of *Mucor Mucedo, Fusarium* sp. *Stereum pupureum,* and *Sclerotinia trifoliorum.* The difference between the irradiated plates and the controls was most marked. This is well illustrated in figure 1, A, B, C, and D, for Mucor and Fusarium. In both cases the mycelium has the appearance of "shrinking" away from the light. Actually, it does

[1] The writers are indebted to Mr. C. W. Williamson for the photographs of the plate cultures and to Mr. W. E. Dant for assistance in the preparation of material.

[2] Fulton, H. R. The fungicidal action of ultra-violet radiation. Jour. Agr. Research. 38: 159–168. 1929.

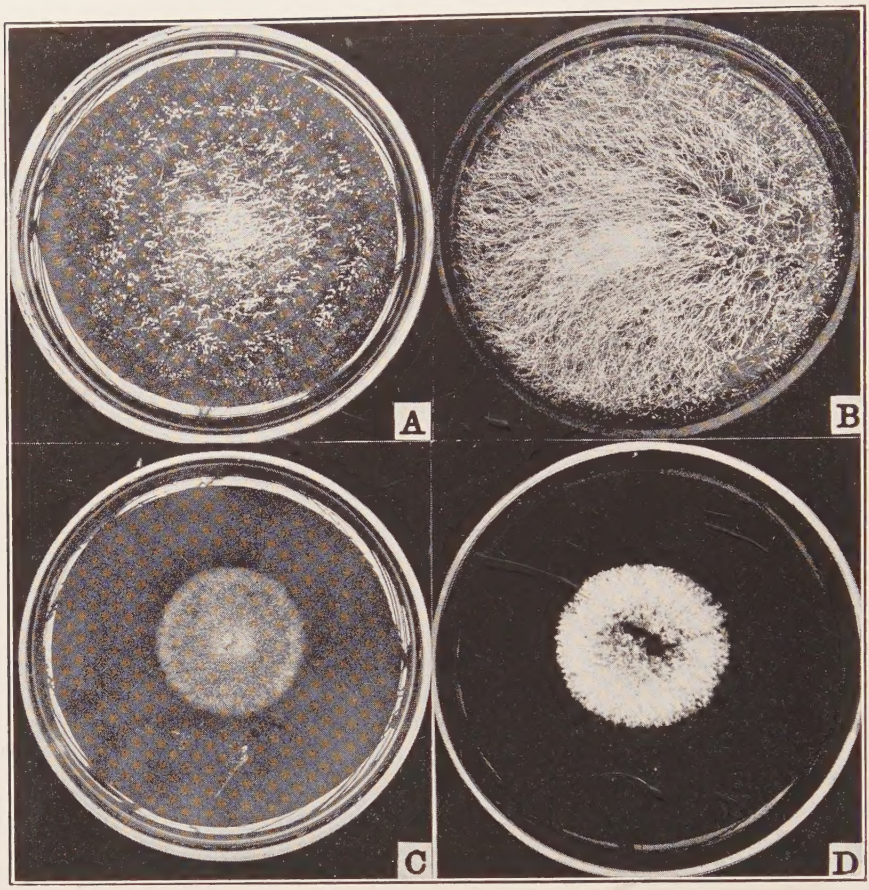

FIG. 1. A. *Mucor mucedo.* Radiated. B. *Mucor mucedo.* Not radiated. C. *Fusarium* sp. Radiated. D. *Fusarium* sp. Not radiated.

grow down farther into the medium, as if hiding from the light; consequently, aerial development is retarded and the sporangiophores and conidiophores appear stunted. After 7 days treatment these plates were reversed and treatment continued for another 7 days (*i.e.*, the plate receiving ultra-violet light was kept as the control and the control was illuminated). The effect of this treatment was to inhibit the growth of the original controls and to encourage growth in the cultures that had originally been retarded by the action of the light. This point is illustrated in figure 2, A, B, C, and D, the same plates as those shown in figure 1, A, B, C, and D, the difference of treatment being as stated, namely, that the former controls had been given light and the ultra-violet cultures had been kept as controls.

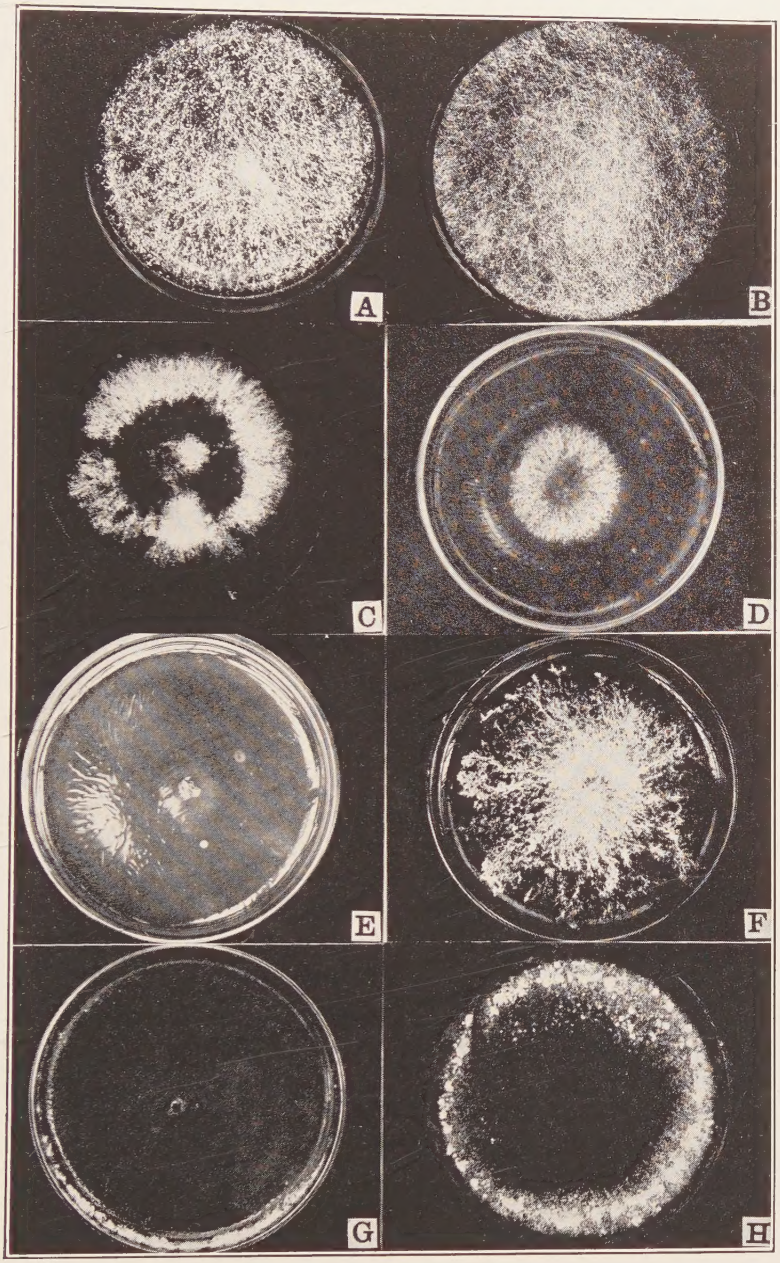

FIG. 2. A. *Mucor mucedo* (see Fig. 1, A). Following nonirradiation. B. *Mucor mucedo* (see Fig. 1, B). Following radiation. C. *Fusarium* sp. (see Fig. 1, C). Following nonirradiation. D. *Fusarium* sp. (see Fig. 1, D). Following radiation. E. *Stereum purpureum*. Radiated. F. *Stereum purpureum*. Not radiated. G. *Sclerotinia trifoliorum*. Radiation. H. *Sclerotinia trifoliorum*. No radiation.

This experiment suggests that in these cases the mycelium is not killed by the light but that growth is inhibited. Fulton,[3] on the other hand, asserts that the mycelium from germinated spores is more easily killed than the resting spores. Our results indicate the probability that in many cases the mycelium may not be killed but rendered dormant for some considerable time. Further experiments to be described will give more evidence on this point.

The effect of ultra-violet light given for 9 minutes per day for 14 days on *Stereum purpureum* was to check further growth and the inference then was that the mycelium had been killed. Figure 2, E and F, illustrates this point: Under similar conditions the rate of growth of *Sclerotinia trifoliorum* was checked, but at the end of the 14 days sclerotia were forming. With this fungus it was interesting to note that, when irradiated with ultra-violet light, the sclerotia were formed at the side of the dish, whereas in the control dishes they were formed much farther away from the side. In both fungi the mycelium grew well down into the medium away from the surfaces. Indeed, in all cases that were dealt with subsequently this was our experience. Figure 2, G and H, illustrates this phenomenon. The plates were photographed after 7 days.

With the other fungi that have been quoted similar results were obtained. Eventually, growth was checked and it was inferred that the mycelium had been killed. This was attributed to the fungicidal power of ultra-violet light. It was noted that the darker colored spores seemed to possess more resistance to light, thus confirming Fulton's observations.

In addition to these fungi, the action of ultra-violet light was tested on the chlamydospores of *Tilletia caries* Tul. produced on Chinese White wheat. The spores were placed on potato-agar medium in petri dishes; the plates intended for irradiation were covered with Sanalux glass. The controls had the normal petri dish cover. The controls were not irradiated, the others being given 9 minutes per day for a week. In the controls the majority of the bunt spores had formed primary conidia, in the case of those radiated; however, development had been checked and few primary conidia were observed.

To confirm the above general findings, 25 watch glasses were half filled with potato agar and then inoculated with *Mucor Mucedo*. A Vita glass plate was placed over these and four strips of carbon paper were pasted on the glass. The cultures were then irradiated for 9 minutes daily for a week with the result that where the watch glasses were covered with the strips of paper growth took place in a perfectly normal manner, but, where they were not covered, very little growth was apparent to the naked eye.

[3] *Loc. cit.*

At this stage preliminary experiments also were started on the action of ultra-violet rays on insects and other minute animals. Saprophytic eelworms from diseased Darwin tulips were placed in water in a watch glass. After one exposure of 9 minutes the majority of the adult eelworms were killed. In somewhat similar experiments the same results were obtained. Work in this direction is now progressing and the results will be communicated in due course.

EXPERIMENTS OF A MORE CONCLUSIVE CHARACTER

Nineteen petri dishes that had previously been exposed for spore-trapping experiments in the air, at altitudes varying from 500 to 13,000 feet, were taken. The contaminations of these were plotted and diagrams of the plates were made. The plates were then exposed for 15 minutes at one foot from the light. One exposure was made with the dish covers removed so that the light was cast directly on the naked culture. Subsequently the contaminations were again plotted and diagrams made when it was noted that the various colonies had not been killed but that more colonies had grown and pre-existing colonies were extending.

ACTION OF ULTRA-VIOLET LIGHT ON STEREUM PURPUREUM

Cultures of *Stereum purpureum* were made on potato agar in 8-cm. petri dishes with Sanalux glass tops. After a lapse of 6 days, in order to allow the fungus to establish itself on the medium, irradiation was commenced. Two series of cultures were irradiated daily, one series at 12 inches from the lamp, the other at 24 inches from the lamp. In each series separate cultures were exposed to the lamp at the following time intervals, 1 minute, 2 minutes, 4, 8, 16, 32, and 64 minutes, respectively. Radiation in this manner was given for 7 days, then the light treatment was stopped. From the records of growth made, it was observed that "the fungicidal action" of the light varied with the time given and the distance away from the lamp. This appeared to confirm Fulton's work; namely, "the killing effect of ultra-violet rays is increased with the lengthening of the time of action and also with the increase in the intensity of the radiation. Decrease in the distance from the source of radiation results in increase in intensity and in consequent killing effect."

In our own experiments we at first inferred that the mycelium had been killed. Subsequent examination 7 days later showed that in each case the fungus had grown and the rate of growth was in proportion to the time of exposure and the distance from the lamp. The mycelium had not been killed, but growth had been checked to the minimum and the fungus had grown away from the light and deep into the medium. Indeed, this could be observed in some cases at the bottom of the petri dish.

The experiment was designed in exactly the same way as the previous one, and the findings were the same. In this and the preceding experiment the control dishes with the ordinary covers had developed normally. For work of this description this fungus is an excellent one, as the rate of growth can easily be determined by the formation of sclerotia. In no case, however, was the mycelium killed. When light radiation ceased, growth was renewed and, as stated, the rate of new growth was in proportion to the time and distance of the previous exposure. It was again interesting to note that, when under the influence of light, the formation of sclerotia took place at the side of the dish.

DISCUSSION

When these results are compared with those obtained by Fulton the following points must be borne in mind.

Fulton made his exposures with the glass tops removed; whereas, in these experiments Sanalux or Vita glass covers were used and these glasses transmit only 50 to 70 per cent of ultra-violet light. Again, Fulton inoculated his media by flooding the surface with spores or by blowing them on with an atomizer, *i.e.*, by surface inoculation only. In our experiments nearly all inoculations were made with a needle, so that spores and mycelium would be carried *into* the medium. Stevens[4] found that the minimum lethal dosage for exposed spores of *Glomerella cingulata* (Stonem.) S. and v. S. was somewhat above 10 but under 15 seconds, while, for spores covered by an agar layer about 15 mm. deep, the lethal period was over 90 seconds.

In our own experiments we at first thought the mycelium had been killed but, later, as we have shown, we realized that the mycelium was not dead but had been gradually checked in its growth and then rendered dormant. In all cases the mycelium grew deep into the medium to avoid the light. This is interesting since, in laboratory experiments that were carried out with *Mucor mucedo* grown in the normal way in petri dishes, the fungus grew towards the light. For example, a culture was made and a piece of carbon paper was pasted on the dish cover. A circular piece was cut from the middle of this disc. Later, it was found that the fungus had grown towards that portion not shaded by the paper. It is clear, therefore, that the different rays of light must have a different effect upon fungal growth.

[4] Stevens, F. L. Effects of ultra-violet rays on various fungi. Bot. Gaz. 86: 210–225. 1928.

It is here suggested that the higher fungi such as many of those in the Basidiomycetes—excluding the Uredinales and Ustilaginales—are intolerant of ultra-violet light and grow better when this is absent. It is an age-old superstition that "mushrooms," for example, grow only in the dark. These fructifications are formed more in the autumn, winter, and spring. It is generally agreed that growth of these and similar fructifications depends very largely upon moisture. It is, however, here further suggested that in damp and wet weather ultra-violet light is at its minimum and, consequently, growth is not inhibited.

SCHOOL OF AGRICULTURE,
CAMBRIDGE, ENGLAND.

Digitized by the Internet Archive
in 2025

https://archive.org/details/fungicidalaction0020ward